JC09 Rec'd PCT/PTO 27 FEB 2001

| FORM PTO-1390 US DEPARTMENT OF COMMERCE<br>REV. 5-93PATENT AND TRADEMARK OFFICE<br>**TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371** | | ATTORNEYS DOCKET NUMBER<br>**P01,0086**<br>U.S. APPLICATION NO. (if known, see 37 CFR 1.5)<br>09/763989 |
|---|---|---|
| INTERNATIONAL APPLICATION NO.<br>**PCT/EP99/06209** | INTERNATIONAL FILING DATE<br>**24 AUGUST 1999** | PRIORITY DATE CLAIMED<br>**28 AUGUST 1998** |

TITLE OF INVENTION

**METHOD AND APPARATUS FOR MEASURING THE TRANSMISSION QUALITY OF A TRANSMISSION CHANNEL**

APPLICANT(S) FOR DO/EO/US

**JOSEF EICHINGER ET AL.**

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay.
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of International Application as filed (35 U.S.C. 371(c)(2)) - drawings attached.
   a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2) - drawings attached.
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. §371(c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☒ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

**Items 11. to 16. below concern other document(s) or information included:**

11. ☒ An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98; **(PTO 1449, Prior Art, Search Report, 03 References)**.
12. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 C.F.R. 3.28 and 3.31 is included. **(SEE ATTACHED ENVELOPE)**
13. ☒ Amendment "A" Prior to Action.
    ☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☒ A substitute specification and substitute specification mark-up.
15. ☒ A change of address letter attached to the Declaration.
16. ☒ Other items or information:

    a. ☒ Appointment of Associate Power of Attorney

    b. ☒ EXPRESS MAIL #EL655301032US dated February 27, 2001.

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| U.S. APPLICATION NO (if known, see 37 C.F.R. 1.5) 09/763989 | INTERNATIONAL APPLICATION NO PCT/EP99/06209 | ATTORNEY'S DOCKET NUMBER P01,0086 |
|---|---|---|

| | | | | CALCULATIONS | PTO USE ONLY |
|---|---|---|---|---|---|
| 17. ☒ The following fees are submitted:<br><br>**BASIC NATIONAL FEE (37 C.F.R. 1.492(a)(1)-(5):**<br>Search Report has been prepared by the EPO or JPO $860.00<br><br>International preliminary examination fee paid to USPTO (37 C.F.R. 1 482) $690.00<br><br>No international preliminary examination fee paid to USPTO (37 C.F.R. 1.482) but international search fee paid to USPTO (37 C.F.R. 1.445(a)(2) $710.00<br><br>Neither international preliminary examination fee (37 C.F.R. 1.482) nor international search fee (37 C.F.R. 1.445(a)(2) paid to USPTO $1000.00<br><br>International preliminary examination fee paid to USPTO (37 C.F.R. 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) $ 100.00 | | | | | |
| **ENTER APPROPRIATE BASIC FEE AMOUNT =** | | | | $ 860.00 | |
| Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 C.F.R. 1.492(e)). | | | | $ | |
| Claims | Number Filed | Number Extra | Rate | | |
| Total Claims | 10 - 20 = | 0 | X $ 18.00 | $ | |
| Independent Claims | 02 - 3 = | 0 | X $ 80.00 | $ | |
| Multiple Dependent Claims | | | $270.00 + | $ | |
| **TOTAL OF ABOVE CALCULATIONS =** | | | | $ 860.00 | |
| Reduction by ½ for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 C.F.R. 1.9, 1.27, 1.28) | | | | $ | |
| **SUBTOTAL =** | | | | $ 860.00 | |
| Processing fee of $130.00 for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). + | | | | $ | |
| **TOTAL NATIONAL FEE =** | | | | $ 860.00 | |
| Fee for recording the enclosed assignment (37 C.F.R. 1.21(h). The assignment must be accompanied by an appropriate cover sheet (37 C.F.R. 3.28, 3.31). $40.00 per property + | | | | | |
| **TOTAL FEES ENCLOSED =** | | | | $ 860.00 | |
| | | | | Amount to be refunded | $ |
| | | | | charged | $ |

a. ☒ A check in the amount of $ 860.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No.________ in the amount of $______ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 50-1519. **A duplicate copy of this sheet is enclosed.**

NOTE: Where an appropriate time limit under 37 C.F.R. 1.494 or 1.495 has not been met, a petition to revive (37 C.F.R. 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

***SEND ALL CORRESPONDENCE TO:***

**SCHIFF HARDIN & WAITE**
**PATENT DEPARTMENT**
**6600 Sears Tower**
**233 South Wacker Drive**
**Chicago, Illinois 60606-6473**

**CUSTOMER NUMBER 26574**

Mark Bergner
**SIGNATURE**

Mark Bergner
**NAME**

45,877
**Registration Number**

09/763989
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BOX PCT
IN THE UNITED STATES DESIGNATED/ELECTED OFFICE
OF THE UNITED STATES PATENT AND TRADEMARK OFFICE
UNDER THE PATENT COOPERATION TREATY--CHAPTER II

**PRELIMINARY AMENDMENT A**
**PRIOR TO ACTION**

| | |
|---|---|
| APPLICANT(S): | Josef Eichinger et al. |
| ATTORNEY DOCKET NO.: | P01,0086 |
| INTERNATIONAL APPLICATION NO: | PCT/EP99/06209 |
| INTERNATIONAL FILING DATE: | 24 August 1999 |

INVENTION: METHOD AND APPARATUS FOR MEASURING THE TRANSMISSION QUALITY OF A TRANSMISSION CHANNEL

Assistant Commissioner for Patents,
Washington D.C. 20231

Sir:

Applicants herewith amend the above-referenced PCT application, and request entry of the Amendment prior to examination on the United States Examination Phase.

**IN THE CLAIMS**:

**On substitute page 10:**

replace line 1 with --WHAT IS CLAIMED IS:--;

Please replace original claims 1-10 with the following rewritten claims 1-10, referring to the mark-ups in Appendix A.

1. (Amended) A method for measuring a transmission quality of a transmission channel via which an information is transmitted, comprising the steps of:

representing said information as symbols;

mapping said symbols onto signal values; and

transmitting said signal values via said transmission channel, forming transmitted signal values;

wherein said receiver implements the steps of:

receiving said transmitted signal values, forming received signal values;

mapping said received signal values onto detected symbols; and

converting said detected symbols into a detected information;

and wherein a measuring comprises the steps of:

forming a reference signal by mapping successive, detected symbols onto signal values; and

calculating said transmission quality of said transmission channel based on said reference signal and on said received signal values.

2. (Amended) The method according to claim 1, wherein said step of calculating said transmission quality comprises the steps of:

determining a noise signal part of said received signal values upon employment of said reference signal; and

calculating the transmission quality of the transmission channel based on said reference signal and said noise signal part.

3. (Amended) The method according to claim 2, wherein said step of calculating said transmission quality further comprises the steps of:

determining an average power of said reference signal and of said noise signal part; and

calculating a signal-to-noise ratio as a criterion for said transmission quality based on said average power of said reference signal and on said average power of said noise signal part.

4. (Amended) The method according to claim 2, wherein said step of calculating said transmission quality further comprises the step of:

determining an average power of said reference signal and of said noise signal part, said step of determining said average power of said noise signal part comprises calculating an average power of a difference of said received signal values and said reference signal.

5. (Amended) The method according to claim 2, wherein said step of calculating said transmission quality further comprises the step of:

determining an average power of said reference signal and of said noise signal part, said average power of said noise signal part being determined by forming a difference of said average power of said received signal values and said average power of said reference signal.

6. (Amended) The method according to claim 3, further comprising the step of allocating a symbol error rate or a bit error rate to said calculated signal-to-noise ratio for specifying a measured value for said transmission quality.

7. (Amended) A transmission system for transmitting digital information, comprising:

a transmitter comprising:

an encoding device for representing said digital information as symbols; and

a modulator for mapping said symbols onto signal values for said transmission via a transmission channel;

a receiver comprising:

a demodulator for mapping received signal values onto detected symbols; and

a decoding device for representing said detected symbols as detected digital information;

and

a device for measuring a transmission quality of said transmission channel for said transmission of digital information comprising:

a modulator for generating a reference signal, in that signal values are allocated to successively detected symbols; and

a transmission quality determination device for determining said transmission quality of said transmission channel based on said reference signal and on said received signal values.

8. (Amended) The transmission system according to claim 7, further comprising:

a device for determining a reference signal average power of said reference signal;

a device for determining a received signal value average power of said received signal values;

a subtractor for subtracting said reference signal average power from said received signal value average power and for generating a noise signal part average power of a noise signal part; and

a divider for calculating a signal-to-noise ratio as a criterion for said transmission quality by division of said reference signal average power by said noise signal part average power.

9. (Amended) The transmission system according to claim 7, further comprising:

a device for determining a reference signal average power of said reference signal;

a subtractor for subtracting said reference signal from said received signal values and for generating a noise signal part;

a device for determining a noise signal part average power of said noise signal part; and

a divider for calculating a signal-to-noise ratio as a criterion for said transmission quality by dividing said reference signal average power by said noise signal part average power.

10. (Amended) A transmission system according to claim 7, further comprising:

an error rate determination device that allocates a symbol error rate or bit error rate to a calculated signal-to-noise ratio.

## REMARKS

The present Amendment revises the specification and claims to conform to United States patent practice, before examination of the present PCT application in the United States National Examination Phase. Pursuant to 37 CFR 1.125 (b), applicants have concurrently submitted a substitute specification, excluding the claims, and provided a marked-up copy. All of the changes are editorial and applicant believes no new matter is added thereby. The amendment, addition, and/or cancellation of claims is not intended to be a surrender of any of the subject matter of those claims.

Early examination on the merits is respectfully requested.

Submitted by,

Mark Bergner (Reg. No. 45,877)

Mark Bergner
Schiff Hardin & Waite
Patent Department
6600 Sears Tower
233 South Wacker Drive
Chicago, Illinois 60606-6473
(312) 258-5779
Attorneys for Applicant

**CUSTOMER NUMBER 26574**

## Appendix A
## Mark Ups for Claim Amendments

This redlined draft, generated by CompareRite (TM) - The Instant Redliner, shows the differences between -
original document : Q:\DOCUMENTS\YEAR 2001\P010086-EICHINGER\ORIGINAL CLAIMS.DOC
and revised document: Q:\DOCUMENTS\YEAR 2001\P010086-EICHINGER\AMENDED CLAIMS.DOC

CompareRite found 194 change(s) in the text

Deletions appear as Overstrike text surrounded by []
Additions appear as Bold-Underline text

1. [~~Method~~]**(Amended)** **A method** for measuring [~~the~~] **a** transmission quality of a transmission channel [~~(4)~~] via which an information is transmitted, **comprising the steps of:** [~~whereby the transmitter implements the following steps:~~
~~--~~]

representing [~~the~~] **said** information [~~in the form of~~] **as** symbols**;**[~~,~~
~~--~~]

mapping [~~the~~] **said** symbols onto signal values**;** and

[~~--~~]transmitting [~~the~~] **said** signal values via [~~the~~] **said** transmission channel[~~(11);~~]**, forming transmitted signal values;**

[~~whereby the~~] **wherein said** receiver implements the [~~following~~] steps **of:**[~~:~~
~~--~~]

receiving [~~the~~] **said** transmitted signal values**, forming**[~~(14),~~
~~-- mapping the~~] received signal values[~~(21)~~]**;**

**mapping said received signal values** onto detected symbols[~~(9)~~]**;** and

[~~--~~]converting [~~the~~] **said** detected symbols [~~(9)~~] into a detected information; and [~~whereby the~~] **wherein a** measuring [~~method~~] comprises the [~~following~~] steps **of:**[~~:~~
~~--~~]

forming a reference signal [~~(15)~~] by mapping successive, detected symbols [~~(9)~~] onto signal values**;** and

[~~--~~]calculating [~~the~~] **said** transmission quality [~~(22, 23)~~] of [~~the~~] **said** transmission channel [~~(4)~~] based on [~~the~~] **said** reference signal [~~(15)~~] and on [~~the~~] **said** received signal values[~~(14)~~].

2. [~~Method~~]**(Amended)** **The method** according to claim 1, [~~characterized in that the step for the calculation of the~~] **wherein said step of calculating said** transmission quality [~~(22) implements~~] **comprises** the [~~following~~] steps **of:**[~~:~~
~~--~~]

determining a noise signal part [~~(27)~~] of [~~the~~] **said** received signal values [~~(14)~~] upon employment of [~~the~~] **said** reference signal**; and**[~~(15);~~
~~--~~]

calculating the transmission quality [~~(22)~~] of the transmission channel [~~(4)~~] based on [~~the~~] **said** reference signal [~~(15)~~] and [~~the~~] **said** noise signal part[~~(27)~~].

3. [~~Method~~]**(Amended)** **The method** according to claim 2, [~~characterized in that, for~~] **wherein said step of** calculating [~~the~~] **said** transmission quality **further comprises the steps of:**

**determining an**[~~,~~
~~-- the~~ ] average power [~~(S, N)~~] of [~~the~~] **said** reference signal [~~(15)~~] and of [~~the~~] **said** noise signal part [~~is determined; and~~]**; and**

[~~-- to~~] **calculating a** signal-to-noise ratio [~~(22) is calculated as~~ ]**as a** criterion for [~~the~~] **said** transmission quality based on [~~the~~] **said** average power [~~(S)~~] of [~~the~~] **said** reference signal [~~(15)~~] and on [~~the~~] **said** average power [~~(N)~~] of [~~the~~] **said** noise signal part.

4. [~~Method~~]**(Amended)** **The method** according to claim 2 [~~or claim 3, characterized in that the average power (N) of the noise signal part is calculated by~~]**, wherein said step of calculating said transmission quality further comprises the step of:**

determining [~~the~~] **an** average power of [~~the difference of the~~] **said reference signal and of said noise signal part, said step of determining said average power of said noise signal part comprises calculating an average power of a difference of said** received signal values [~~(14)~~] and [~~the~~] **said** reference signal[~~(15).~~]**.**

[~~5. Method~~] **5. (Amended) The method** according to claim 2 [~~or claim 3, characterized in that the average power (N) of the~~ ]**, wherein said step of calculating said transmission quality further comprises the step of:**

**determining an average power of said reference signal and of said** noise signal part [~~is~~]**, said average power of said noise signal part being** determined by forming [~~the~~] **a** difference of [~~the~~] **said** average power [~~(S+N)~~] of [~~the~~] **said** received signal values [~~(14)~~] and [~~the~~] **said** average power [~~(S)~~] of [~~the~~] **said** reference signal[~~(15).~~]**.**

[~~6. Method~~] **6. (Amended) The method** according to [~~one of the claims 3 through 5, characterized in that~~] **claim 3, further comprising the step of allocating** a symbol error rate [~~(23)~~] or **a** bit error rate [~~is allocated to the~~] **to said** calculated signal-to-noise ratio [~~(22)~~] for specifying a measured value for [~~the~~] **said** transmission quality.

7. [~~Transmission~~]**(Amended) A transmission** system for [~~the transmission of~~] **transmitting** digital information, comprising**:**

a transmitter **comprising:**[~~(10) that contains:~~

~~--~~]

an encoding device for representing [~~the~~] **said** digital information [~~in the form of~~] **as** symbols[~~,~~]**;** and

[

~~--~~]a modulator for mapping [~~the~~] **said** symbols onto signal values for [~~the~~] **said** transmission via a transmission channel[~~(4);~~]**;**

[~~and comprising~~] a receiver **comprising:**[~~(12) that contains:~~

~~--~~]

a demodulator [~~(20)~~] for mapping received signal values [~~(14)~~] onto detected symbols[~~(9)~~]; and

[

~~--~~]a decoding device [~~(24)~~] for representing [~~the~~] **said** detected symbols [~~(9)~~] as detected digital information;

and

[~~comprising~~] a device for measuring [~~the~~] **a** transmission quality of [~~a~~] **said** transmission channel [~~(4)~~] for [~~the~~] **said** transmission of digital information[~~, whereby said device contains:~~

~~--~~] **comprising:**

a modulator for generating a reference signal[~~(15)~~], in that signal values are allocated to successively detected symbols[~~(9),~~]**;** and

[~~--~~]a transmission quality determination device [~~(11)~~] for determining [~~the~~] **said** transmission quality [~~(22, 23)~~] of [~~the~~] **said** transmission channel [~~(4)~~] based on [~~the~~] **said** reference signal [~~(15)~~] and on [~~the~~] **said** received signal values[~~(14).~~]**.**

[~~8. Apparatus~~] **8. (Amended) The transmission system** according to claim 7, **further comprising:** [~~characterized in that the apparatus also comprises:~~

~~--~~]

a device [~~(24)~~] for determining [~~the~~] **a reference signal** average power [~~(S)~~] of [~~the~~] **said** reference signal**;**[~~(15),~~

~~--~~]

a device [~~(29)~~] for determining [~~the~~] **a received signal value** average power [~~(S+N)~~] of [~~the~~] **said** received signal values**;**[~~(14),~~

~~--~~]

a subtractor [~~(30)~~] for subtracting [~~the~~] **said reference signal** average power [~~(S) of the reference~~] **from said received** signal [~~(15) from the~~] **value** average power

~~[(S+N) of the received signal values (14)]~~ and for generating ~~[the]~~ **a noise signal part** average power ~~[(N)]~~ of a noise signal part~~[,]~~**;** and

~~[--]~~a divider ~~[(28)]~~ for calculating ~~[the]~~ **a** signal-to-noise ratio ~~[(22)]~~ as **a** criterion for ~~[the]~~ **said** transmission quality by division of ~~[the]~~ **said reference signal** average power ~~[(S) of the reference signal (15) by the average power (N) of the]~~ **by said** noise signal part **average power.**

**9. (Amended) The transmission system**~~[.~~

~~9. Method]~~ according to claim 7, **further comprising:** ~~[characterized in that the apparatus also comprises:~~

~~--]~~

a device ~~[(24)]~~ for determining ~~[the]~~ **a reference signal** average power ~~[(S)]~~ of ~~[the]~~ **said** reference signal**;**~~[(15),~~

~~--]~~

a subtractor ~~[(26)]~~ for subtracting ~~[the]~~ **said** reference signal ~~[(15)]~~ from ~~[the]~~ **said** received signal values ~~[(14)]~~ and for generating a noise signal part**;**~~[,~~

~~--]~~

a device ~~[(25)]~~ for determining ~~[the average power (N) of the]~~ **a** noise signal part~~[, and~~

~~--]~~ **average power of said noise signal part; and**

a divider ~~[(28)]~~ for calculating ~~[the]~~ **a** signal-to-noise ratio ~~[(22)]~~ as **a** criterion for ~~[the]~~ **said** transmission quality by dividing ~~[the]~~ **said reference signal** average power ~~[(S) of the reference signal (15) by the average power (N) of the]~~ **by said** noise signal part **average power.**

**10. (Amended) A transmission system**~~[.~~

~~10. Apparatus]~~ according to ~~[one of the claims 7 through 9, characterized in that the apparatus also comprises]~~ **claim 7, further comprising:**

an error rate determination device [~~(12)~~] that allocates a symbol error rate [~~(23)~~] or bit error rate to a calculated signal-to-noise ratio[~~(22)~~].

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**SPECIFICATION**

**METHOD AND APPARATUS FOR MEASURING THE TRANSMISSION QUALITY OF A TRANSMISSION CHANNEL**

The invention is directed to a method and to a corresponding apparatus for measuring the transmission quality in a transmission of digital information via a transmission channel.

The need for digital transmission systems has exponentially risen in recent decades. Digital transmission systems are generally classified into the function units shown in Fig. 1. A message source 1 generates information that is transmitted by a transmitter via a transmission channel 4 to a receiver. The properties of the information to be transmitted are dependent on the message source. Messages to be transmitted can, for example, be an audio signal or a video signal. Analog transmission signals thereby transmit analog signals that were generated by analog message sources, transmitting these directly via the transmission channel upon employment of traditional analog modulation methods. Such modulation methods are, for example, amplitude modulation, frequency modulation or phase modulation. In digital transmission systems, the information to be transmitted is converted into a sequence of binary numbers. In order to be able to utilize the capacity of the channel optimally well, the message to be transmitted should be represented with as few binary numbers as necessary. To this end, a source encoder is employed that has the job of converting the messages to be transmitted into sequences of signal values and encoding them, so that the channel can transmit them. The source encoder thereby attempts to convert the messages to be transmitted into binary numerals as efficiently as possible. The sequence of binary numbers generated by the source encoder is transmitted by the channel to the receiver. Such an actual channel can, for example, be composed of a line connection, of a coaxial cable, of a light waveguide (LWL), of a radio connection, a satellite channel or a combination of these transmission media. Such channels cannot directly transmit the sequence of binary numbers from the transmitter. To that end, the sequence of digital information must be converted into signal values that correspond to the properties of the channel. Such a device

is called a digital modulator. Such a modulator is part of the channel encoder 3, which additionally comprises a discrete channel encoder in order to provide the information to be transmitted with an error protection adapted to the channel.

It is not assumed of the transmission channel 4 that it works error-free; rather, it is assumed that a noise source 5 will modify the transmitted signals during the transmission with a specific probability.

Such disturbances can, for example, be a cross-talk of signals that are transmitted on neighboring channels. The disturbances can likewise be caused by thermal noise that is generated in the electronic circuit such as, for example, amplifiers and filters that are employed in the transmitter and in the receiver. Given line connections, disturbances can additionally be caused by switchings and can be additionally caused by meteorological influences given radio or satellite connections such as, for example, thunderstorms, hail or snow. Such influences modify the transmitted signal and cause errors in the received digital signal sequence.

In order to nonetheless assure a relatively dependable transmission, the channel encoder increases the redundancy of the (binary) sequence to be transmitted. With the assistance of this redundancy added by the transmitter, the receiver is assisted in the decoding of the information-carrying signal sequence. To this end, for example, the channel encoder combines a specific plurality of signals to form blocks and a plurality of check signals (one parity bit in the simplest case) is added. In this way, k information bits are always simultaneously encoded, whereby each k bit sequence has an unambiguous n bit sequence, what is referred to as the code word, allocated to it. The redundancy added in this way can be indicated with the ratio n/k. This likewise corresponds to the channel bandwidth that must be correspondingly increased in order to transmit the information sequence expanded by the added redundancy.

Alternatively, an enhanced dependability against channel disturbances can also be achieved, for example, by an increase in the transmission power. Since the increase in the transmission power, however, is relatively expensive, the dependability is usually achieved given available bandwidth by increasing the required channel bandwidth.

In the transmission of one bit with the data rate R bit/s, the modulator always allocates a signal curve or, respectively, a signal value (referred to below only as signal value) $s_1(t)$ to the binary number 0 and allocates a signal value $s_2(t)$ to the binary number 1. This transmission of each individual bit by the channel encoder is called binary modulation. Alternatively, the modulator can simultaneously transmit k information bits upon employment of $M = 2^k$ different signal values $s_i(t)$ with $i = 1, 2, \ldots M$, whereby each of the $2^k$ possible k-bit sequences is allocated to a signal value.

At the receiver side of a digital transmission system, the digital demodulator processes the signal value transmitted in the channel (potentially modified) and allocates an individual number to each signal value that represents an estimate of the transmitted data symbol (for example, binary).

After reception of a signal in the receiver, the demodulator must decide which of the M possible signal values was sent. This decision is implemented in a decision unit (slicer), whereby the decision should be made with minimal error probability. This decision unit allocates a reception value (usually edited) to one of the M possible symbol values.

When, for example, a binary modulation is employed, the demodulator must decide when processing each received signal whether the transmitted bit is a matter of a 0 or of a 1. In this case, the demodulator implements a binary decision. Alternatively, the demodulator can also implement a ternary decision, whereby the demodulator decides for "0", "1" or "no decision" dependent on the quality of the received signal.

The decision process of a demodulator can be viewed as quantization, whereby binary and ternary decisions are specific instances of a demodulation that quantizes Q-level, whereby $Q \geq 2$ applies. In general, digital communication systems employ a high-order modulation, whereby $m = 0, 1 \ldots M\text{-}1$ represents the possible transmitted symbols.

When the transmitted information contains no redundancy, the demodulator must decide at every predetermined time interval which of the M-signal values was transmitted. When the transmitted information, in contrast, contains redundancy, then the demodulator reconstructs the original information

sequence on the basis of the code employed by the channel encoder and on the basis of the redundancy of the received signals. Dependent on the demands defined by the applications, the channel encoder generates signal blocks that make it possible for the channel decoder to either only identify where the specific disturbances have occurred (error-recognizing encoding) or to even be able to automatically correct (error-correcting encoding) errors caused by disturbances (up to a specific maximum number per signal block).

One criterion for the dependability with which the messages are transmitted from the transmitter to the receiver is represented by the error rate. The error rate indicates the average probability with which a bit error occurs at the output of the decoder. The bit error rate indicates the plurality of error bits occurring at the receiver divided by the total number of received bits per time unit. The bit error rate (or symbol error rate when the error frequency of symbols is evaluated) is the most important quality criterion of a digital transmission system. In general, the error probability is dependent on the code properties, on the nature of the signal values employed for the transmission of the information via the channel, on the transmission power, on the properties of the channel, i.e. the strength of the noise, the type of noise, etc., and on the demodulation and decoding method. The significance of the bit error rate for digital transmission systems corresponds to the signal-to-noise ration (SNR) of analog transmission systems.

Traditionally, a known bit sequence or, respectively, symbol sequence is transmitted at periodic time intervals for determining the error rate, being transmitted in addition to the transmitted information and also be known to the receiver. Such a signal is generally composed of a pseudo-random sequence of suitable length. The error rate can be determined in the receiver in that a comparison of the transmitted signal to the received signal is implemented (rated-actual comparison).

An object of the invention is to create an improved method and an improved apparatus for measuring the transmission quality of a digital transmission channel.

This object is achieved for a method with the technical teaching of claim 1 and is achieved for an apparatus with the technical teaching of claim 7.

Advantageous developments of the invention are recited in the subclaims.

Inventively, a signal value is again allocated to each detected symbol in the demodulator at the receiver side, namely a signal value that the input of the decision unit in the demodulator would have received if the signal curve or, respectively, signal value corresponding to the detected signal had been transmitted unfalsified. In this way, a hypothetical input signal corresponding to the detected symbol values is formed that contains no signal values with channel distortions. This reference signal, as long as the decision unit does not detect false symbols, thus corresponds to the original signal at the transmission side. By subtracting this reference signal from the actually received signal, the noise signal can be acquired. With the assistance of these two signal parts, the quality of the transmission channel can be defined. The average power of this reference signal formed in this way thus corresponds to the average power of the received, undisturbed signal part. The average power of the received signal corresponds to the combination of disturbed and undisturbed signal parts. With the assistance of the previously calculated, undisturbed signal part, the reference signal, the noise power is calculated therefrom. The signal-to-noise ratio (SNR) derives from the ratio of the average power of the undisturbed signal part to the average power of the noise part, deriving as a criterion for the transmission quality of the transmission channel.

What this invention particularly avoids is that the receiver must know a specific transmission sequence, as necessary in traditional methods. Moreover, the determination of the error rate ensues parallel with the evaluation of the transmitted symbols, i.e. online. A periodic introduction of a measuring sequence into the data stream to be transmitted is therefore no longer required for the continuous measurement of the transmission quality. In this way, a reduction of the net data rate of the transmission channel can be avoided.

In order to assure a high statistical dependability, the traditional method that employs a test sequence known to the transmitter and receiver must acquire a great plurality of errors, usually a few hundred. For the extremely low bit error

rates of, for example, $10^{-9}$ that are generally required, the traditional methods need very long measuring times in order to detect a corresponding plurality of errors. The inventive method, in contrast, is based on the interpretation of the measured signal-to-noise ratio during the ongoing transmission. Since, however, significantly shorter measuring times are required for the interpretation of the average powers than for the comparable evaluation of the symbol stream or, respectively, bit stream of the test sequences, the transmission quality can be identified far, far faster with the inventive method.

The invention thus enables a monitoring of the actual error rate at noticeably shorter time intervals since the actually transmitted information cannot be employed traditionally for determining the error rate and, thus, one must wait for the occurrence of transmission errors in the test sequences that are only rarely introduced.

In a further development of the invention, the identified transmission quality, the signal-to-noise ratio (SNR), can be converted into a symbol or, respectively, bit error rate dependent on the respectively employed encoding method.

Preferred exemplary embodiments of the invention are explained next with reference to the drawing. Shown are:

Fig. 1 the general structure of a message transmission system;

Fig. 2 the structure of an inventive receiver;

Fig. 3 the structure of an inventive demodulator of the receiver shown in Fig. 2;

Fig. 4 the structure of devices for determining the transmission quality of the transmission channel in the receiver shown in Fig.2;

Fig. 5 a device for allocating an identified transmission quality to an error rate in the receiver shown in Fig. 2; and

Fig. 6 a diagram of characteristics for the allocation of a signal-to-noise ratio to the probability of a symbol error dependent on the modulation method employed.

In digital information transmission, information are transmitted between a message source (transmitter) and a receiver via a transmission medium. Such an

apparatus that is located between the transmitter and the receiver is generally referred to as channel.

For the transmission, the data to be transmitted are converted into code words that are matched to the transmission properties of the message channel in order to protect the data to be transmitted against, among other things, transmission errors.

In the transmission, a character, which is generally referred to as symbol in the signal space or channel symbol, is allocated to a bit sequence with a reversibly unambiguous, functional allocation. This symbol is subsequently mapped onto a signal curve (referred to below as signal value) allocated to this symbol. The functional allocation of a symbol to a bit sequence in the transmitter is called encoding or mapping; the mapping of such a symbol or of a plurality of such symbols onto a signal value is called modulation.

The reversal of this mapping sequence occurs in the receiver. During the demodulation, i.e. the allocation of a reception signal to a symbol, can usually not be implemented error-free due to distortions or superimposed disturbances of the channel, the decoding, i.e. the conversion of a detected symbol into the corresponding bit sequence does not represent any problems. Fig. 2 shows an inventive receiver that comprises a demodulator 10, a signal-to-noise ratio identification means 11 and an error rate identification means 12. The demodulator processes the received signal 13 in order to output a corresponding bit sequence 16 at its output. Such a demodulator 10 contains a decision unit 18 that allocates one or more symbols 9 or, respectively, the corresponding signal value 15 to the edited reception value 14 following the analog and the optional first steps of the digital signal processing (combined here to form the block "signal editing" 17). The signal-to-noise ratio identification means 11 shown in Fig. 2 contains two different identification devices 20, 21 in order to identify a signal-to-noise ratio 22. An error rate 23 is allocated to the identified signal-to-noise ratio 22 in the error rate identification means 12 dependent on the respective encoding method.

Fig. 3 shows the structure of an inventive demodulator in the receiver of a digital transmission system. The signal 13 received from the transmission

channel 4 is supplied to a signal editing device 17 that, for example, contains the analog-to-digital conversion needed for the digital signal processing and/or a distortion correction of the transmitted signals. The edited signal values 14 are subsequently supplied to the position unit 18 that, using this signal value, decides which symbol or symbols were most probably transmitted. The selected symbol or symbols 9 are conducted to the decoder 19 by the decision unit, said decoder 19 converting the symbols 9 into the bit sequence 16.

The representation of the symbol values at the output 15 of the decision unit 18 shown in Fig. 2 or, respectively, Fig. 3 is identical to the corresponding signal values of the detected symbol, i.e. the signal values predetermined by the modulation in the transmitter. This signal value sequence 15 which is based on the detected symbols 9 is simultaneously forwarded - together with the detected signal value 14 - to a signal-to-noise ration identification means 11 and/or to the preceding signal editing unit 17.

Such a signal-to-noise ratio identification means 11 is shown in Fig. 4. The illustrated identification means contains two versions (version 1, version 2) for calculating the signal-to-noise ratio 22. In an inventive receiver, it suffices to identify the signal-to-noise ratio in only one way.

Whereas the detected signal values 14 contain a signal part and a noise part, the signal values 15, which were identified based on the detected symbols 9, contain only the signal part. In both alternatives (version 1, version 2), the signal part S is divided by the noise part N (noise) in a division device 28 in the signal-to-noise ration identification means 11. To this end, the average signal part S and the average noise power N must be respectively present independently of one another. The average signal power S is identified in the device 24 for determining the average power, being identified from the signal values 15 both according to version 1 as well as according to version 2.

For determining the noise power N, the signal part must be subtracted from the combined signal and noise part of the signal values 14. To that end, the signal values of the reference signal 15 are subtracted from the detected signal values 14 in the first embodiment (version 1) in order to obtain the noise signal

values. The noise signal values are converted into the average power N, 27 of the noise signal in the device 25 for determining the average power.

In the second alternative embodiment, version 2, the average power S + N of the received signal values 14 is first calculated in the device 29. Subsequently, the average power of the signal part calculated in the device 24 is subtracted in the subtraction device 30. The average powers S and N or, respectively, 27 are conducted to the division device 28 that forms the ratio of the average powers of signal part S and noise part N, what is referred to as the signal-to-noise ratio (SNR) 22. This signal-to-noise ratio (SNR) indicates the quality of the transmission of digital information via the transmission channel. Since, differing from analog transmission signals, one does usually not speak of signal-to-noise ration or, respectively, signal-to-noise ratio SNR [sic] given digital transmission channels but generally utilizes the bit error rate or symbol error rate for evaluating the quality of a transmission system, a device 12 is inventively provided that converts the identified signal-to-noise ratio 22 into the generally standard symbol error rate (or bit error rate) 23. To that end, the identified SNR value 22 is converted into the desired symbol error rate 23 with a known mapping rule 24 in Fig. 5.

The mapping rule to be respectively employed is dependent on the encoding method and modulation method employed. A few known characteristics for converting the signal-to-noise ratio SNR into the probability for a symbol error $P_M$ are shown in Fig. 6. Each characteristic thereby corresponds to a different encoding method. M thereby denotes the plurality of different possible signal values, QAM and PSK stand for different encoding methods; PSK denotes "phase shift keying" and QAM stands for quadrature amplitude demodulation.

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JC03 Rec'd PCT/PTO 27 FEB 2001



**Patent Claims**

1. Method for measuring the transmission quality of a transmission channel (4) via which an information is transmitted,
whereby the transmitter implements the following steps:

-- representing the information in the form of symbols,
-- mapping the symbols onto signal values and
-- transmitting the signal values via the transmission channel (11);

whereby the receiver implements the following steps:

-- receiving the transmitted signal values (14) [sic],
-- mapping the received signal values (21) onto detected symbols (9) and
-- converting the detected symbols (9) into a detected information;

and whereby the measuring method comprises the following steps:

-- forming a reference signal (15) by mapping successive, detected symbols (9) onto signal values and
-- calculating the transmission quality (22, 23) of the transmission channel (4) based on the reference signal (15) and on the received signal values (14).

2. Method according to claim 1, characterized in that the step for the calculation of the transmission quality (22) implements the following steps:

-- determining a noise signal part (27) of the received signal values (14) upon employment of the reference signal (15);
-- calculating the transmission quality (22) of the transmission channel (4) based on the reference signal (15) and the noise signal part (27).

3. Method according to claim 2, characterized in that, for calculating the transmission quality,

-- the average power (S, N) of the reference signal (15) and of the noise signal part is determined; and
-- to signal-to-noise ratio (22) is calculated as criterion for the transmission quality based on the average power (S) of the reference signal (15) and on the average power (N) of the noise signal part.

4. Method according to claim 2 or claim 3, characterized in that the average power (N) of the noise signal part is calculated by determining the

average power of the difference of the received signal values (14) and the reference signal (15).

5. Method according to claim 2 or claim 3, characterized in that the average power (N) of the noise signal part is determined by forming the difference of the average power (S+N) of the received signal values (14) and the average power (S) of the reference signal (15).

6. Method according to one of the claims 3 through 5, characterized in that a symbol error rate (23) or bit error rate is allocated to the calculated signal-to-noise ratio (22) for specifying a measured value for the transmission quality.

7. Transmission system for the transmission of digital information, comprising a transmitter (10) that contains:

-- an encoding device for representing the digital information in the form of symbols, and
-- a modulator for mapping the symbols onto signal values for the transmission via a transmission channel (4);

and comprising a receiver (12) that contains:

-- a demodulator (20) for mapping received signal values (14) onto detected symbols (9); and
-- a decoding device (24) for representing the detected symbols (9) as detected digital information;

and comprising a device for measuring the transmission quality of a transmission channel (4) for the transmission of digital information, whereby said device contains:

-- a modulator for generating a reference signal (15), in that signal values are allocated to successively detected symbols (9), and
-- a transmission quality determination device (11) for determining the transmission quality (22, 23) of the transmission channel (4) based on the reference signal (15) and on the received signal values (14).

8. Apparatus according to claim 7, characterized in that the apparatus also comprises:

-- a device (24) for determining the average power (S) of the reference signal (15),

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- a device (29) for determining the average power (S+N) of the received signal values (14),
- a subtractor (30) for subtracting the average power (S) of the reference signal (15) from the average power (S+N) of the received signal values (14) and for generating the average power (N) of a noise signal part, and
- a divider (28) for calculating the signal-to-noise ratio (22) as criterion for the transmission quality by division of the average power (S) of the reference signal (15) by the average power (N) of the noise signal part.

9. Method according to claim 7, characterized in that the apparatus also comprises:

- a device (24) for determining the average power (S) of the reference signal (15),
- a subtractor (26) for subtracting the reference signal (15) from the received signal values (14) and for generating a noise signal part,
- a device (25) for determining the average power (N) of the noise signal part, and
- a divider (28) for calculating the signal-to-noise ratio (22) as criterion for the transmission quality by dividing the average power (S) of the reference signal (15) by the average power (N) of the noise signal part.

10. Apparatus according to one of the claims 7 through 9, characterized in that the apparatus also comprises an error rate determination device (12) that allocates a symbol error rate (23) or bit error rate to a calculated signal-to-noise ratio (22).

**Abstract**

Method and Apparatus for Measuring the Transmission Quality of a Transmission Channel

The transmission quality, particularly the symbol or, respectively, bit error rate, that a digital transmission channel makes available can be determined with traditional methods in that a known bit or, respectively, symbol sequence that is also known to the receiver is transmitted. The error rate can then be determined in the receiver by a rated-actual comparison. Inventively, an online measured value of the transmission quality is determined in that the signal-to-noise ratio of the average powers of an undisturbed and of a disturbed signal is formed. The symbol or, respectively, bit error rate can be calculated from the signal-to-noise ratio. The quality measurement is based thereon that signal values from the set of signal values that are also valid in the receiver are allocated anew to the detected symbols in the receiver, and these signal values are subsequently compared to the actually transmitted signal values.

Figure 2

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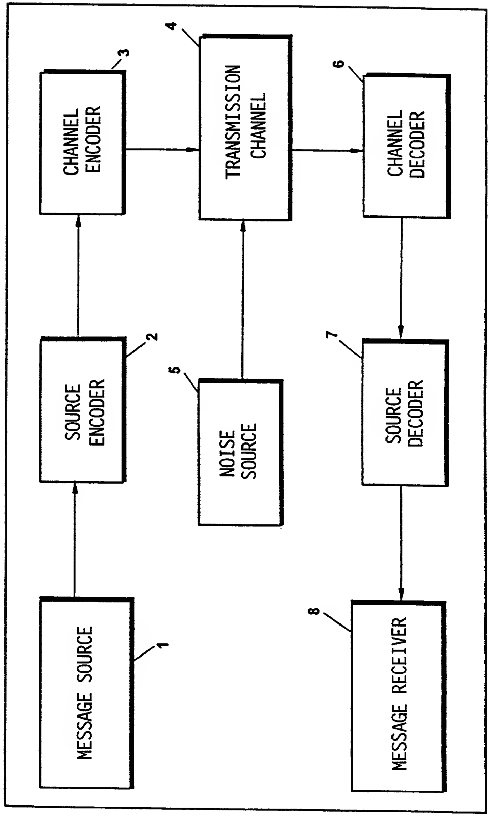


Fig. 1

Fig. 2

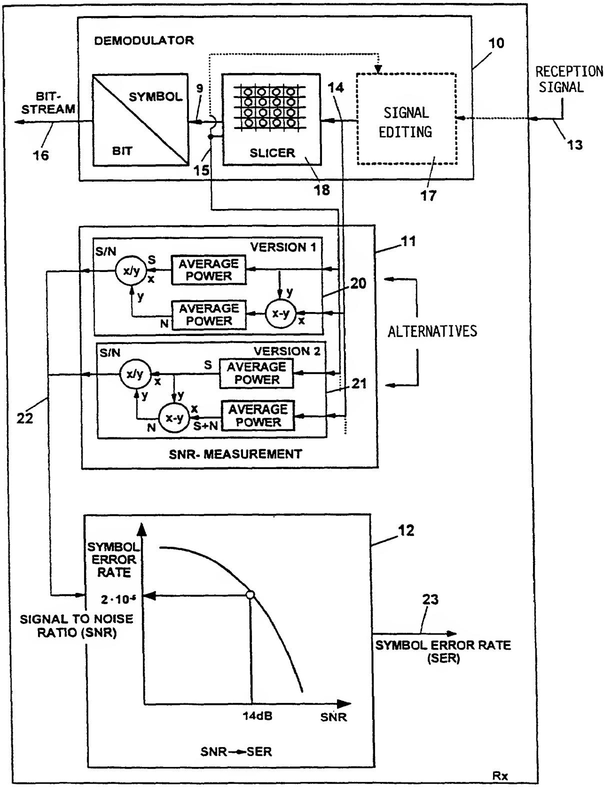
DEMODULATOR
10
RECEPTION
SIGNAL
BIT-
STREAM
SYMBOL
9
14
SIGNAL
EDITING
BIT
SLICER
16
15
18
17
13
11
S/N
VERSION 1
x/y
S
x
y
AVERAGE
POWER
AVERAGE
POWER
N
x-y
20
ALTERNATIVES
S/N
VERSION 2
x/y
S
AVERAGE
POWER
AVERAGE
POWER
x-y
S+N
N
21
22
SNR- MEASUREMENT
12
SYMBOL
ERROR
RATE
2·10-5
SIGNAL TO NOISE
RATIO (SNR)
23
SYMBOL ERROR RATE
(SER)
14dB
SNR
SNR→SER
Rx

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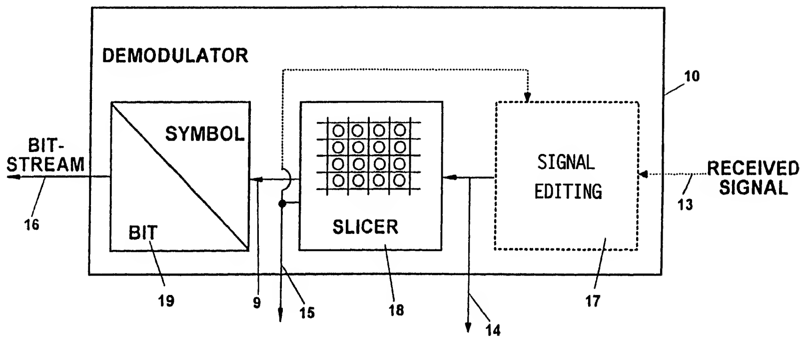
Fig. 3



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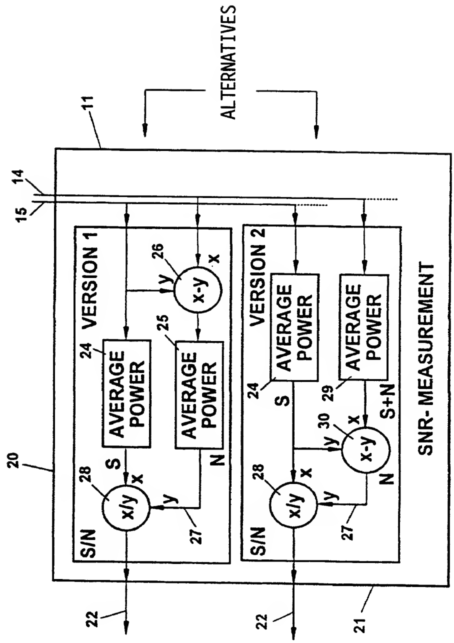



Fig. 4

Fig. 5

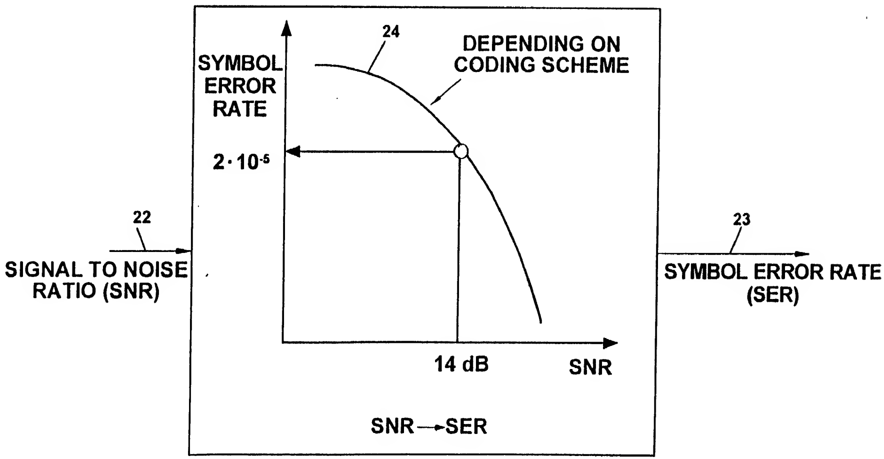
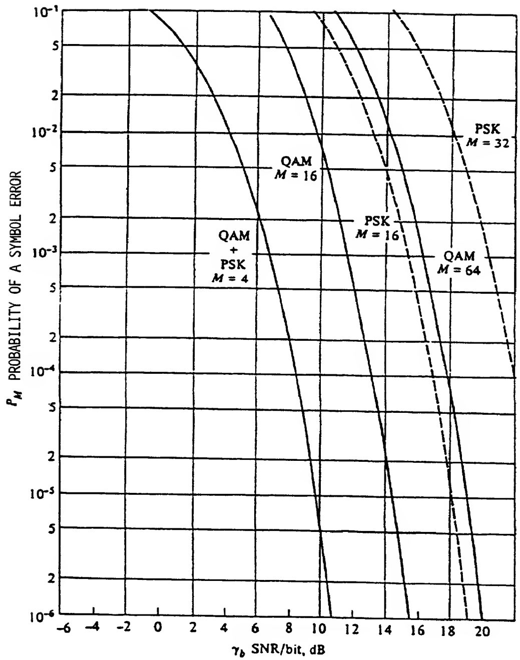

SIGNAL TO NOISE RATIO (SNR)
22
SYMBOL ERROR RATE
2·10-5
24
DEPENDING ON CODING SCHEME
14 dB
SNR
SNR → SER
23
SYMBOL ERROR RATE (SER)

*Fig. 6*



$10^{-1}$
5
2
$10^{-2}$
5
2
$10^{-3}$
5
2
$10^{-4}$
5
2
$10^{-5}$
5
2
$10^{-6}$
$P_M$ PROBABILITY OF A SYMBOL ERROR
-6 -4 -2 0 2 4 6 8 10 12 14 16 18 20
$\gamma_b$ SNR/bit, dB
QAM + PSK $M = 4$
QAM $M = 16$
PSK $M = 16$
QAM $M = 64$
PSK $M = 32$

# Declaration and Power of Attorney For Patent Application
## *Erklärung Für Patentanmeldungen Mit Vollmacht*
### German Language Declaration

Als nachstehend benannter Erfinder erkläre ich hiermit an Eides Statt:

As a below named inventor, I hereby declare that:

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My residence, post office address and citizenship are as stated below next to my name,

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I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Verfahren und Vorrichtung zur Messung der Übertragungsqualität eines Übertragungskanals

deren Beschreibung

the specification of which

(zutreffendes ankreuzen)

(check one)

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☐ is attached hereto.

☐ am ____________ als PCT internationale Anmeldung PCT Anmeldungsnummer ____________ eingereicht wurde und am ____________ abgeändert wurde (falls tatsächlich abgeändert)

☐ was filed on ____________ as PCT international application PCT Application No. ____________ and was amended on ____________ (if applicable)

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I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims as amended by any amendment referred to above.

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I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

Ich beanspruche hiermit ausländische Prioritätsvorteile gemass Abschnitt 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 119 aller unten angegebenen Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde, und habe auch alle Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde nachstehend gekennzeichnet, die ein Anmeldedatum haben, das vor dem Anmeldedatum der Anmeldung liegt, für die Prioritat beansprucht wird.

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Prior foreign appplications
Priorität beansprucht

Priority Claimed

| | | | | |
|---|---|---|---|---|
| 198 39 307.5 | Germany | 28. August 1998 | ☒ | ☐ |
| (Number) (Nummer) | (Country) (Land) | (Day Month Year Filed) (Tag Monat Jahr eingereicht) | Yes Ja | No Nein |
| | | | ☐ | ☐ |
| (Number) (Nummer) | (Country) (Land) | (Day Month Year Filed) (Tag Monat Jahr eingereicht) | Yes Ja | No Nein |
| | | | ☐ | ☐ |
| (Number) (Nummer) | (Country) (Land) | (Day Month Year Filed) (Tag Monat Jahr eingereicht) | Yes Ja | No Nein |

Ich beanspruche hiermit gemäss Absatz 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 120, den Vorzug aller unten aufgeführten Anmeldungen und falls der Gegenstand aus jedem Anspruch dieser Anmeldung nicht in einer fruheren amerikanischen Patentanmeldung laut dem ersten Paragraphen des Absatzes 35 der Zivilprozeßordnung der Vereinigten Staaten, Paragraph 122 offenbart ist, erkenne ich gemäss Absatz 37, Bundesgesetzbuch, Paragraph 1 56(a) meine Pflicht zur Offenbarung von Informationen an, die zwischen dem Anmeldedatum der früheren Anmeldung und dem nationalen oder PCT internationalen Anmeldedatum dieser Anmeldung bekannt geworden sind.

I hereby claim the benefit under Title 35. United States Code. §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §122, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occured between the filing date of the prior application and the national or PCT international filing date of this application.

| | | | |
|---|---|---|---|
| (Application Serial No ) (Anmeldeseriennummer) | (Filing Date) (Anmeldedatum) | (Status) (patentiert, anhängig, aufgegeben) | (Status) (patented, pending, abandoned) |
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POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

And I hereby appoint

(16) Messrs. John D Simpson (Registration No. 19,842) Lewis T. Steadman (17,074), William C. Stueber (16,453), P. Phillips Connor (19,259), Dennis A. Gross (24,410), Marvin Moody (16,549), Steven H Noll (28,982), Brett A Valiquet (27,841), Thomas I. Ross (29,275), Kevin W. Guynn (29,927), Edward A. Lehmann (22,312), James D Hobart (24,149), Robert M. Barrett (30,142), James Van Santen (16,584), J. Arthur Gross (13,615), Richard J. Schwarz (13,472) and Melvin A. Robinson (31,870), David R. Metzger (32,919), John R. Garrett (27,888) all members of the firm of Hill, Steadman & Simpson, A Professional Corporation.

Telefongespräche bitte richten an *(Name und Telefonnummer)*

Direct Telephone Calls to: *(name and telephone number)*

312/876-0200
Ext. ______________

Postanschrift:

Send Correspondence to:

HILL, STEADMAN & SIMPSON
A Professional Corporation
85th Floor Sears Tower, Chicago, Illinois 60606

1-00

| Voller Name des einzigen oder ursprunglichen Erfinders<br>EICHINGER, Josef | Full name of sole or first inventor: |
|---|---|
| Unterschrift des Erfinders — Datum<br>Eichinger Josef 1.9.99 | Inventor's signature — Date |
| Wohnsitz<br>D-85~~5~~464 Neufinsing, Germany DEX | Residence |
| Staatsangehörigkeit<br>Bundesrepublik Deutschland | Citizenship |
| Postanschrift<br>Pfarrer-Eitlinger-Ring 5 | Post Office Addess |
| D-8~~5~~4564 Neufinsing<br>Bundesrepublik Deutschland | |

2-00

| Voller Name des zweiten Miterfinders (falls zutreffend):<br>HALEMANN, Rüdiger | Full name of second joint inventor, if any: |
|---|---|
| Unterschrift des Erfinders — Datum<br>R. Halfmann 10.8.99 | Second Inventor's signature — Date |
| Wohnsitz<br>D-67697 Otterberg, Germany DEX | Residence |
| Staatsangehorigkeit<br>Bundesrepublik Deutschland | Citizenship |
| Postanschrift<br>Glashütterstr. 13 | Post Office Address |
| D-67697 Otterberg<br>Bundesrepublik Deutschland | |

*(Bitte entsprechende Informationen und Unterschriften im Falle von dritten und weiteren Miterfindern angeben).*

*(Supply similar information and signature for third and subsequent joint inventors).*

3-00

| Voller Name des dritten Miterfinders: LIEGL, Werner | Full name of third joint inventor: |
|---|---|
| Unterschrift des Erfinders · Datum 10.8.99 | Inventor's signature · Date |
| Wohnsitz: D-85247 Schwabhausen, Germany DEX | Residence |
| Staatsangehörigkeit: Bundesrepublik Deutschland | Citizenship |
| Postanschrift: Blumenstr. 4 | Post Office Address |
| D-85247 Schwabhausen<br>Bundesrepublik Deutschland | |
| Voller Name des vierten Miterfinders (falls zutreffend) | Full name of fourth joint inventor, if any: |
| Unterschrift des Erfinders · Datum | Inventor's signature · Date |
| Wohnsitz | Residence |
| Staatsangehörigkeit | Citizenship |
| Postanschrift | Post Office Address |
| | |
| Voller Name des funften Miterfinders (falls zutreffend). | Full name of fifth joint inventor, if any· |
| Unterschrift des Erfinders · Datum | Inventor's signature · Date |
| Wohnsitz | Residence |
| Staatsangehörigkeit | Citizenship |
| Postanschrift | Post Office Address |
| | |
| Voller Name des sechsten Miterfinders (falls zutreffend) | Full name of sixth joint inventor, if any: |
| Unterschrift des Erfinders · Datum | Inventor's signature · Date |
| Wohnsitz | Residence |
| Staatsangehörigkeit | Citizenship |
| Postanschrift | Post Office Address |
| | |

*(Bitte entsprechende Informationen und Unterschriften im Falle von dritten und weiteren Miterfindern angeben)*

*(Supply similar information and signature for third and subsequent joint inventors).*